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# A new design of UHF tag antenna for clothing identification using SRR

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## ABSTRACT

In this paper, we present a new antenna for radio frequency identification (RFID) tag operating in the Moroccan ultra high frequency (UHF) band around 868 MHz, this antenna is designed on a flexible plastic substrate of relative permittivity 3 and low tangential losses which is 0.002. The proposed tag is designed to identify clothing in supermarkets. The tag antenna has a miniature size of 38 mm in length and 26 mm in width. This miniature size was obtained by using two rectangular split ring resonator (RSRR). The impedance matching of the RFID chip with the antenna was carried out by a double T-matching structure. The antenna is designed, simulated and optimized using computer simulation technology (CST) microwave studio software and good results have been obtained in terms of impedance matching, gain and read range.

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## 1. INTRODUCTION

That makes it possible to identify an object, an animal or a human being, to follow its path or to know its characteristics remotely using a tag attached or incorporated in the object and reflecting radio waves [1]. Nowadays, radio frequency identification (RFID) technology has many applications in many fields and is based on several standards and regulations. For instance, we quote: animal tracking, supply chain, distribution, access control, libraries and so on [2], [3].

An RFID system comprises three main parts are a host system, a reader, and a tag or a transponder. The Tag is composed of an electronic chip which contains coded information on the object and an antenna for the communication with the reader, as well as a battery in the case of active tags or not in the case of passive tags. A block diagram of an RFID system is shown in Figure 1 [4]. Despite the benefits provided by RFID technology, their growth remains hampered by the unit cost of a tag that presents a major obstacle, especially when it is compared to the global reference identification system that is the barcode [5]-[8]. Indeed, in some applications, the objects to be identified maysometimes have a unit price lower than the price of the RFID tag. To reduce the cost of an RFID tag and view that theantenna represents a cost that is very important compared to the RFID chip, we proposed to miniaturize its size to reduce the general cost of the RFID tag [9]-[13].

There are several methods of miniaturization proposed by many researchers such as, the fractal method, the use of slits,nthe folding technique [13]-[19], but the miniaturization with most of these methods introduces some drops in the antennanperformances. In this paper we proposed to use metamaterial split ring resonator (SRR) to reduce the antenna size. The rest of this paper is organized as follows: in the first section, we present an overview of metamaterials, in the second section, we present the antenna design and in the last part we present the results and the discussion.

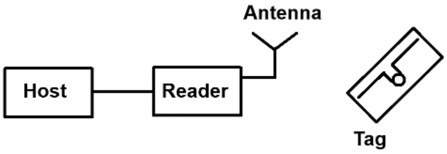
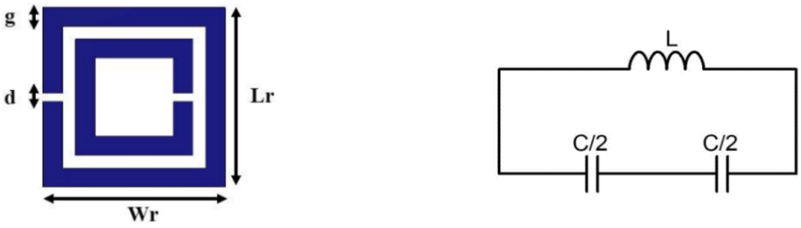


Figure 1. Block diagram of an RFID system

## 2. METAMATERIAL OVERVIEW

Metamaterials are attracting an increasing interest from researchers in the fields of microwaves, antennas and radio frequencies. These revolutionary materials artificially manufactured from metallic and dielectric patterns of dimensions much smaller than the wavelength allow to obtain unique, fascinating and extraordinary electromagnetic properties impossible to find in natural materials such as negative permittivity and or negative permeability [20]. The properties of metamaterials have made it possible to improve the performance of microwave circuits such as filters, couplers, power dividers and antennas while offering the potential to miniaturize their size, to improve their bandwidth and their gain and expand the read range of radio communications circuits [21], [22].

The theoretical concept of the metamaterials was introduced by Veselago in the sixties [20], but it took 30 years to see the first realizations of this kind of material with Dr. Smith who proposed a network of tin wire (TW) to obtain a negative permittivity and split-ring resonators (SRR) to obtain a negative permeability. His work has attracted the attention of several researchers who have proposed new structures in several forms are triangular, rectangular, and circular [23]. The structure used in this work is a split ring resonator, these geometric parameters are presented in Figure 2 (a). With Wr represents the width, Lr represents the length, d represents the gap and g represents the width of the ring. This SRR unit cell can be transformed by an equivalent circuit using capacitor and inductor elements as illustrated in Figure 2 (b).



(a) (b)

Figure 2. The rectangular split ring resonator: (a) physical structure and (b) equivalent circuit

## 3. ANTENNA DESIGN

A passive RFID tag consists of three main part: an antenna, an RFID chip and an impedance matching circuit for maximizing the power transmitted between the antenna and the microchip. In section 3.1 we will present the RFID chip used for this work and in section 3.2 we will present the matching circuit with the proposed antenna.

### 3.1. RFID Microchip

Each RFID chip has its own properties that are unique. For this reason, each RFID tag antenna is designed to work with a particular chip. In order to design an RFID tag for a certain application, the choice of an RFID chip must take into account: standards, information storage capacity, cost, and performance. In this work, we will use the commercial chip "NXP Alien H3", having an input impedance Zc=27-j110 Ohms, dedicated for passive tags and smart labels, and supporting the standard electronic product code (EPC)

Global Class1 Gen2, the minimum threshold power to enable the chip is -20 dBm. It is ideally suitable for supply chain management applications and some applications requiring operating distances of several meters. Theoretically, this RFID chip can be modeled electrically by a series RC-circuit as shown in Figure 3 (a) or parallels RC-circuit as presented in Figure 3 (b). The parameters Rp, Rs, Cp, and Cs are computed from (1), (2), (3), and (4) [24], [25].

$$Rs = \mathrm{Re(Zc)} \tag{1}$$

$$Cs = \frac{1}{2.\pi.f.\mathrm{Im}(Zc)} \tag{2}$$

$$Rp = \frac{\mathrm{Re}(Ze)^2+\mathrm{Im}(Zc)^2}{\mathrm{Re}(Zc)} \tag{3}$$

$$Cp = \frac{\mathrm{Im}(Zc)}{2.\pi.f.(\mathrm{Re}(Zc)^2+\mathrm{Im}(Zc)^2)} \tag{4}$$

(a) (b)

Figure 3. Equivalent circuit of RFID microchip: (a) series model and (b) parallels model

### 3.2. Antenna geometry

In this section, we present the followed approach for designing the proposed antenna. The proposed antenna is composed of the SRR metamaterial unit cell and the NXP Alien H3 RFID chip having a highly capacitive impedance. In order to maximize the energy transfer between the SRR unit cell and the RFID chip, a double T-matching circuit is used as illustrated in Figure 4. Antenna parameters are optimized using the computer simulation technology (CST) microwave studio software and are reported in Table 1. The general structure of the proposed antenna is presented in Figure 5. This antenna has a miniature and compact size about 38x26x0.175 mm and easy to manufacture and has good performance which will be discussed in section 4.

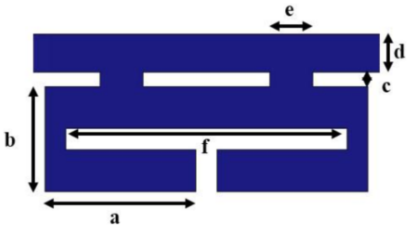


Figure 4. Double T-matching circuit

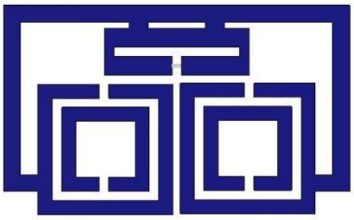


Figure 5. Proposed tag antenna

Table 1. Dimensions of double T-matching parameters

| Parameter | Dimension (mm) |
|---|---|
| a | 7.125 |
| b | 5 |
| c | 0.7 |
| d | 1.8 |
| e | 2 |
| f | 13.25 |

## 4. RESULTS AND DISCUSION

After optimizing the proposed antenna parameters, we present in this section the achieved results in terms of reflection coefficient, antenna input impedance, gain, radiation pattern, and read range. We start with the input impedance which represents the maximum power transferred between the RFID chip and the antenna. The commercial chip has an input impedance Zc=27-j27 Ohms, so the antenna input impedance Za must be equal to the conjugate of Zc. The obtained simulation results are shown in Figure 6. From this figure, we can note that the impedance of the antenna Za=27+j113 Ohms at the Moroccan ultra high frequency (UHF) RFID band 868 MHz, which is close to the conjugate of Zc. The obtained results in terms of the reflection coefficient are shown in Figure 7. From this figure, it is remarkable that the antenna represents a good impedance matching of -22 dB at the resonant frequency.

The radiation patterns in both H and E planes are shown respectively in Figures 8 (a) and 8 (b). It can be clearly seen that the antenna has bidirectional radiation which is suitable for RFID clothing identification applications. In order to understand the effect of each part of the antenna, we drew the surface current distribution as illustrated in Figure 9. It can be noticed that the maximum of the current is observed around the metamaterial unit cells and the double T-matching circuit which justify the use of these structures.

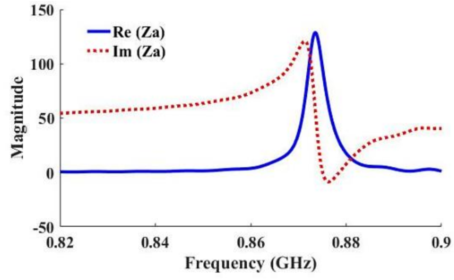


Figure 6. Proposed tag antenna input impedance

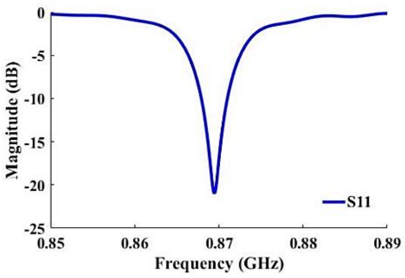
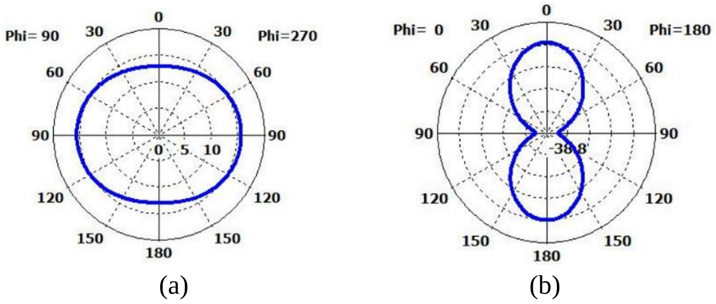


Figure 7. Return loss of the proposed tag antenna



(a) (b)

Figure 8. Radiation pattern of the proposed tag antenna: (a) H-plane and (b) E-plane

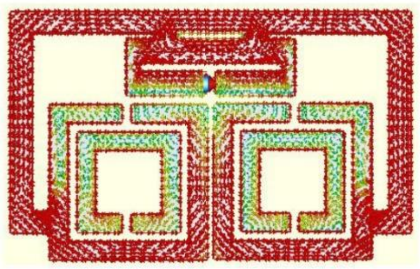


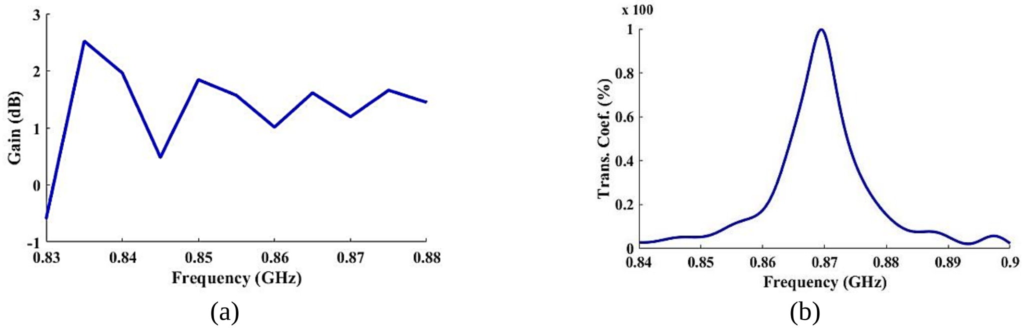
Figure 9. Current distribution of the proposed tag antenna

The gain of the proposed antenna against frequency is in Figure 10 (a). Even though the antenna has a miniature size, it represents a gain that is acceptable about 1.22 dB at the operating frequency. Another important feature is the antenna read range, which is calculated using the Friss formula [21].

$$D\max = \frac{c}{4.\pi.f}\sqrt{\frac{EIRP.\tau.Gt}{Pth}} \quad (5)$$

This parameter is calculated using the antenna gain Ga, the isotropic radiated power equivalent isotropic radiated power (EIRP), the operating frequency f, the speed of the light c and the power transmission coefficient which represents the impedance matching of the antenna with the RFID chip. This coefficient is shown in Figure 10 (b), as we can see in the figure, we have a good impedance matching around 100% at the operating frequency. The range of this antenna is around 20 m. Figure 11 illustrates the read range against frequency.

In order to study the effect of the antenna's environment on its performance, we have studied the antenna read range on different kind of textiles such as polyester, cotton, and elano wool. Figure 12 illustrates the antenna in the presence of a textile piece. The computed results in terms of reading range are reported in Figure 13. From this figure, we can notice that the antenna performance remains unchanged even though in the presence of different kinds of textile which is suitable for clothing identification.



(a) (b)

Figure 10. Simulated results of the tag antenna: (a) gain Vs. frequency and (b) transmission Vs. frequency

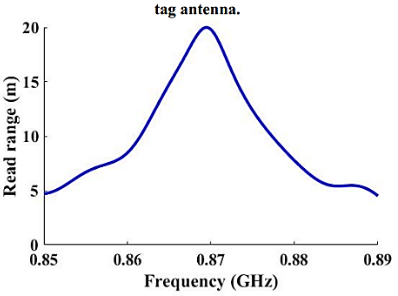


Figure 11. Read range Vs. frequency of the proposed tag antenna

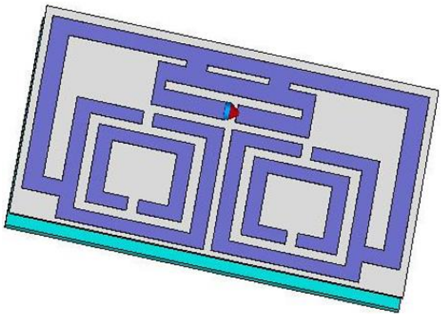


Figure 12. Proposed antenna in presence of a textile substrate

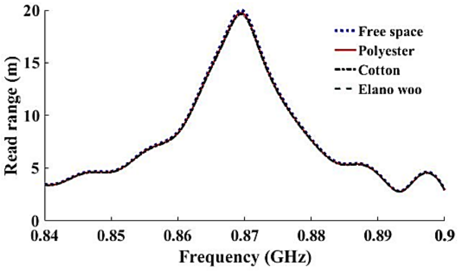


Figure 13. Proposed antenna in presence of a textile substrate

## 5. CONCLUSION

In this paper, we presented a new structure antenna for clothing identification operating at the UHF RFID Moroccan band around 868 MHz. The proposed antenna has a compact and miniature size of 26x38x0.175 mm. The miniaturization of this antenna has been obtained by using split ring resonator metamaterial structures. Generally, the RFID tags are sensitive to the surrounding environment and in order to validate the antenna performance in different environments, we have studied the antenna performance in free space and in presence of a piece of textile and good results have been obtained in terms of, gain, read range and impedance matching.

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